A BIOLOGICAL ASSESSMENT OF SITES ON JACKSON CREEK, JENNIES FORK, AND GRANITE CREEK MONTANA

Project TMDL-M09

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A report to

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by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in September 2002 from sites on Jackson Creek in Jefferson County, Montana and on Jennies Fork and Granite Creek in Lewis and Clark County, Montana. The study sites lie within the Montana Valley and Foothill Prairies ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected September 11, 2002 by Montana DEQ personnel. Sample designations and site locations are indicated in Table 1a. The site selection and sampling method employed were those recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). The traveling-kick collection procedure was employed for all samples; duration and length are indicated in Table 1b. Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the

Table 1a. Sample designations and locations. Jackson Creek, Jennies Fork, and Granite Creek September 11, 2002.

Site	Station ID	Activity ID	Location Description	Latitude/ Longitude
JC	M09JCKSC02	02-U328-M	Jackson Creek	46°28'18.5"/111°51'10.4"
JF	M09JENYF02	02-U336-M	Jennies Fork downstream of ski parking	46°45'09.2"/112°18'40.8"
GC	M09GRNTC01	02-U337-M	Granite Creek	46°38'27.4"/112°17'09.8"

Table 1b. Sample collection procedure, duration, and length. Jackson Creek, Jennies Fork, and Granite Creek September 11, 2002.

Site	Date	Collection Procedure	Duration	Length
JC	9-11-02	KICK	Not legible	Not legible
JF	9-11-02	KICK	1:25 MINUTES	30 FEET
GC	9-11-02	KICK	Not legible	Not legible

values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the three streams in this study. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able

to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. Plecoptera (stonefly) taxa richness. Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. Trichoptera (caddisfly) taxa richness. Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. Number of sensitive taxa. Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).

5. Percent filter feeders. Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998a).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the

benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).

- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Habitat Assessment

Table 4 shows the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied. Figure 1 graphically compares total habitat assessment scores for the three sites.

Overall habitat conditions scored optimally at the site on Jackson Creek, despite the observation of sediment deposition and embeddedness of benthic substrate. Streambank and riparian zone parameters were apparently undisturbed.

At Jennies Fork, benthic substrate diversity was perceived to be marginal, but field notes suggest that substrate met expectations for a stream of small size. Channel alteration in the form of an upstream culvert was noted. Streambanks were judged stable, with adequate vegetative protection. Some abbreviation of riparian zone width was assessed.

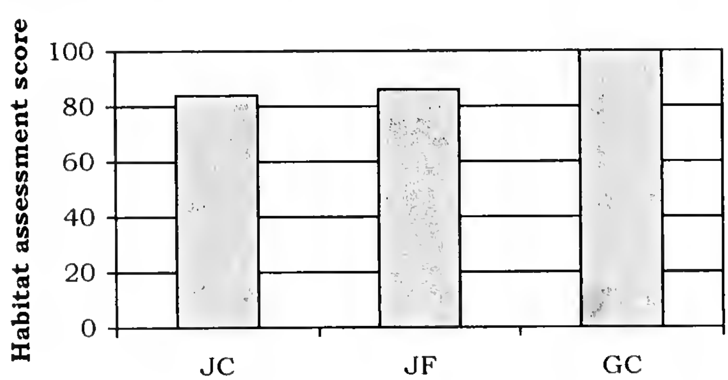
All instream, streambank, and riparian zone parameters received maximal assessment scores at the site on Granite Creek. Overall habitat was perceived to be optimal here.

Table 4. Stream and riparian habitat assessment. The three sites in this study were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. Jackson Creek, Jennies Fork, and Granite Creek. September 11, 2002.

Max. possible score	Parameter	JC	JF	GC
10	Riffle development	10	9	10
10	Benthic substrate	7	5	10
20	Embeddedness	11	19	20
20	Channel alteration	18	10	20
20	Sediment deposition	10	19	20
20	Channel flow status	19	20	20
20	Bank stability	10 / 10	10 / 10	10 / 10
20	Bank vegetation	10 / 10	10 / 10	10 / 10
20	Vegetated zone	10 / 10	8 / 8	10 / 10
160	Total	135	138	160
	Percent of maximum	**84%**	**86%**	**100%**
	CONDITION*	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989).

Figure 1. Total habitat assessment scores for sites on Jackson Creek, Jennies Fork, and Granite Creek. September 11, 2002.



Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the three sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b show criteria for impairment classifications (Plafkin et al. 1989) and use-support categories recommended by Montana DEQ (Bukantis 1998).

When this bioassessment method is applied to these data, results suggest that the site on Jennies Fork was slightly impaired and partly supported designated uses. Sites on both Jackson Creek and Granite Creek appeared to be non-impaired and fully supportive of designated uses.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

The rich mayfly fauna (9 taxa) collected at the site on Jackson Creek (JC) included at least 2 sensitive taxa, and the biotic index value (2.15) was low. These findings suggest that water quality was excellent here. Six cold-stenotherm taxa were among the sampled assemblage. Cold, clean water apparently provided an adequate matrix for a healthy community.

Eighteen "clinger" taxa and 8 caddisfly species were collected, implying that sediment deposition did not substantially limit the availability of clean stony substrates. Twenty-six percent of collected animals were in sediment sensitive taxa. These included the caddisfly *Glossosoma* sp., and four species in the genus *Rhyacophila*. Stonefly taxa richness, which may be related to the integrity of reach-scale habitat features, was lower than expected for a montane stream. Streambank stability, riparian zone function, or natural channel morphology may have been subject to disturbance. The large number (10 taxa) and abundance (11% of sampled animals) of predatory taxa, along with the high overall taxa richness (29), suggest that instream habitats were

Figure 2. Comparison of total bioassessment scores (reported as percent of maximum score) for sites on Jackson Creek, Jennies Fork, and Granite Creek. September 11, 2002. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998a) was used to calculate scores.

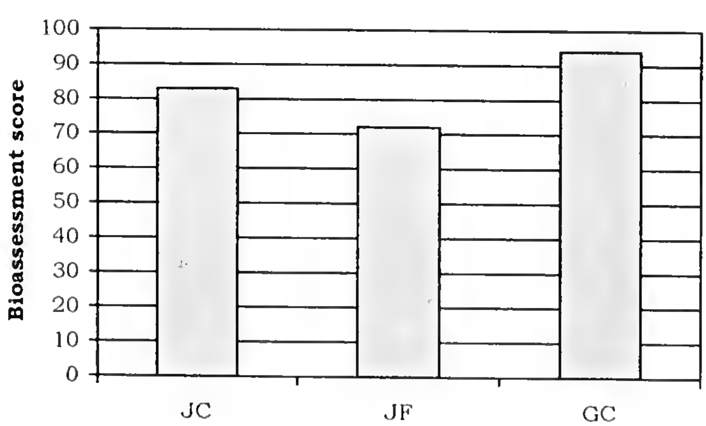


Table 5. Metric values, scores, and bioassessments for sites on Jackson Creek, Jennies Fork, and Granite Creek. September 11, 2002. Site locations are given in Table 1. The revised Montana Valley and Foothill Prairies bioassessment method (Bollman 1998a) was used to calculate scores.

	SITES		
	JC	**JF**	**GC**
METRICS		**METRIC VALUES**	
Ephemeroptera richness	9	4	6
Plecoptera richness	3	5	6
Trichoptera richness	8	4	10
Number of sensitive taxa	6	3	8
Percent filterers	8.85	0.31	2.76
Percent tolerant taxa	7.87	21.32	8.62
		METRIC SCORES	
Ephemeroptera richness	3	2	3
Plecoptera richness	2	3	3
Trichoptera richness	3	2	3
Number of sensitive taxa	3	2	3
Percent filterers	2	3	3
Percent tolerant taxa	2	1	2
TOTAL SCORE (max.=18)	15	13	17
PERCENT OF MAX.	**83%**	**72%**	**94%**
Impairment classification*	**NON**	**SLI**	**NON**
USE SUPPORT †	**FULL**	**PART**	**FULL**

* Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

diverse and plentiful. Four long-lived taxa were present; it is likely that year-round surface flow characterizes the site. All expected functional components were present in adequate proportions.

On Jennies Fork, the number of mayfly taxa (4) taken in the sample was fewer than expected, and the biotic index value (3.51) was slightly elevated. Some water quality impairment is implied by these data. Sensitive organisms were represented by 3 taxa, including the perlodid stonefly *Megarcys* sp. and the dipteran *Glutops* sp. Twenty-one percent of collected animals were tolerant. Three cold-stenothermic taxa were collected. Slight nutrient enrichment may be present, but thermal impairment appears to be unlikely. The abundance of *Pericoma* sp., a fly larva, suggests that calcium may enrich these waters. Groundwater influence may be substantial at this site, since turbellarians were a dominant part of the benthic fauna.

Excellent overall taxa richness (36) and an abundance of predators (27% of animals, 8 taxa) suggest that instream habitats were diverse. However, only 9 "clinger" taxa were present, and caddisfly taxa richness was somewhat lower than expected. Sediment deposition may have lessened the availability of stony substrates for colonization. Another factor which may compromise biotic integrity at this site is

suggested by the dearth of long-lived taxa. Only 2 semivoltine taxa were collected; low richness in this group can be the result of periodic dewatering, or other catastrophes that result in interruptions of long life cycles. Reach-scale habitat features were likely intact, since the site supported no fewer than 5 stonefly taxa. Functionally, the assemblage was dominated by collectors. The proportion of shredders was lower than expected; riparian inputs of large organic material may have been limited, or perhaps hydrologic conditions did not favor retention of such material.

The site on Granite Creek supported a diverse and sensitive benthic assemblage characteristic of an unimpaired montane stream. Eight cold-stenothermic taxa were among those collected; these included the caddisfly *Neothremma* sp., and the stonefly *Doroneuria* sp. Six mayfly taxa were present, and the biotic index value (3.29) was within expectations. Cold, clean water appears to have been the rule here.

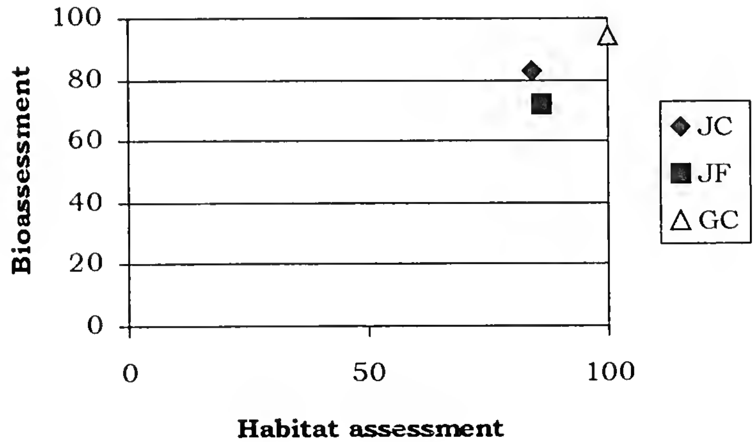
Instream habitat parameters suggested ideal conditions. Twenty "clinger" taxa and 10 caddisfly taxa imply the ample presence of hard substrates unimpaired by sediment deposition. The presence of immature capniid stoneflies suggests that benthic substrates are unembedded by fines, and that hyporheic habitats are accessible. The availability of instream habitats of all sorts is reflected in the high taxa richness (38) and abundance and richness of the predator fauna (11 taxa, 17% of the sampled assemblage). Reach-scale habitat features such as riparian zone function, natural channel morphology, and streambank integrity were likely intact, since 6 stonefly taxa were collected. Long-lived taxa were well-represented (6 taxa), suggesting that year-round flow supported semivoltine life cycles. The functional mix was made up of all expected components in expected proportions.

CONCLUSIONS

- Good water quality and essentially undisturbed instream habitats were suggested by the taxonomic and functional composition of benthic samples collected at Jackson Creek and Granite Creek.
- Some evidence of mild nutrient enrichment was evident at Jennies Fork. In addition, instream habitats may have been affected by sediment deposition.

- Figure 3 graphs the relationship between habitat assessment scores and bioassessment scores for the sites sampled in this study (after Barbour and Stribling 1991). The symbol for Jennies Fork demonstrates the situation where habitat assessment predicts a higher than actual bioassessment score. This suggests that water quality impairment may affect benthic integrity at the site.

Figure 3. Total bioassessment scores plotted against habitat assessment scores (Barbour and Stribling 1991) for three sites on Jackson Creek, Jennies Fork, and Granite Creek September 11, 2002.



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